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## "Pervasive $\text{NO}_x$ " in the Troposphere

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$\text{NO}_y$  /  $\text{NO}_x$  relationships in the GMI simulations:

*Where does true remote-atmosphere  $\text{NO}_x$  come from and  
what determines the lowest simulated levels?*

*Import: Tropospheric  $\text{O}_3$  production (and OH levels) are most sensitive  
to changes in  $\text{NO}_x$  at low (1-50 ppt) levels; PDF of  $\text{NO}_x$  is important*

(1) Observed vs. modeled  $\text{HNO}_3/\text{NO}_x$  and  $\text{PAN}/\text{NO}_x$

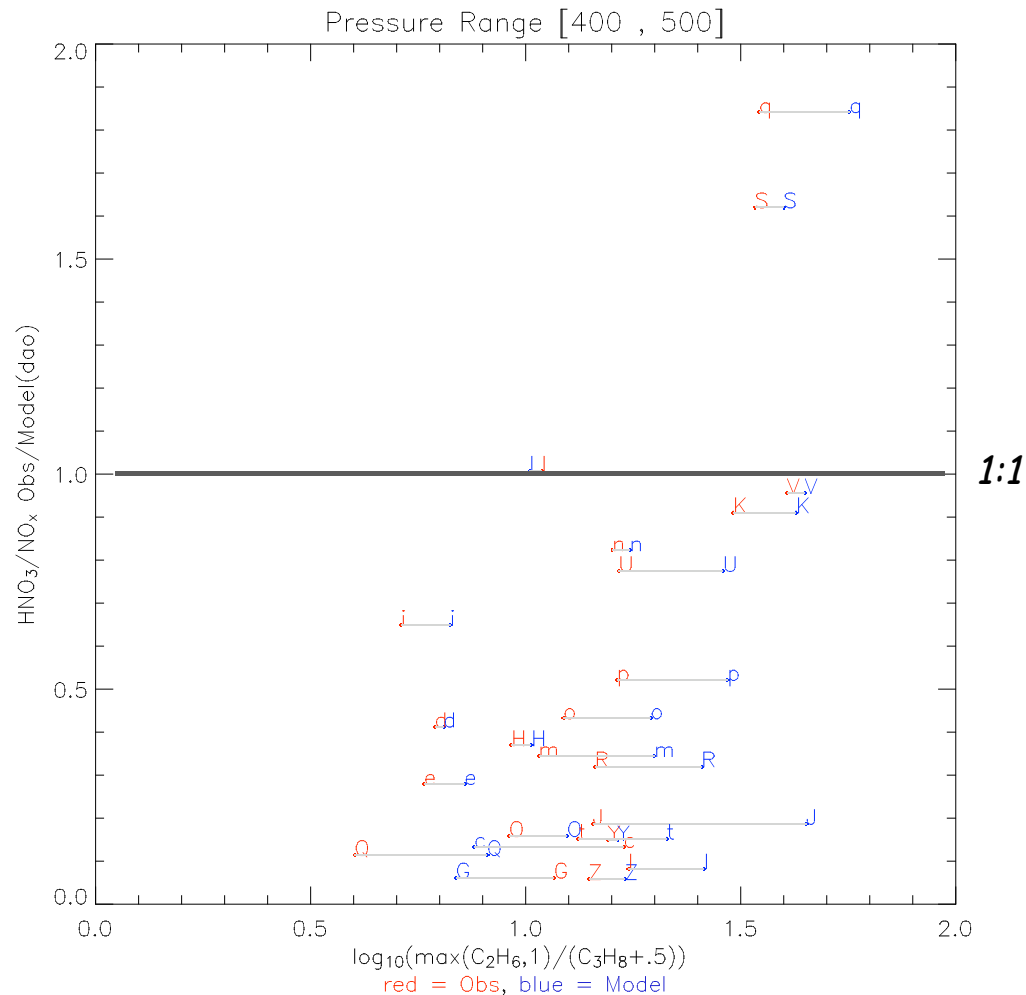
- observations about tropospheric "age of air"

(2)  $\text{NO}_x$  from aircraft: one day's flights:

ignoring diel variation equivalent to huge horizontal misplacement

## Obs Regions

B Alaska+ABLE-3A  
 C Calif+CITE-2  
 D Calif+Coast+CITE-1B  
 E Canary+Islands+POLINAT-2  
 F Central-US+SUCCESS  
 G China+Coast+PEM-West-A  
 H China+Coast+PEM-West-B  
 I China+Coast+TRACE-P  
 J Christmas+Island+PEM-Tropics-A  
 K Christmas+Island+PEM-Tropics-B  
 L E-Atlantic+POLINAT-2  
 M E-Brazil+ABLE-2A  
 N E-Brazil+ABLE-2B  
 O E-Brazil+TRACE-A  
 P E-Brazil+Coast+TRACE-A  
 Q EAtlantic+SONEX  
 R Easter+Island+PEM-Tropics-A  
 S Easter+Island+PEM-Tropics-B  
 T Europe+POLINAT-2  
 U Fiji+PEM-Tropics-A  
 V Fiji+PEM-Tropics-B  
 W Hawaii+CITE-1B  
 X Hawaii+PEM-Tropics-A  
 Y Hawaii+PEM-Tropics-B  
 Z Hawaii+PEM-West-A  
 a Ireland+POLINAT-2  
 b Ireland+SONEX  
 c Japan+PEM-West-A  
 d Japan+PEM-West-B  
 e Japan+TRACE-P  
 f Labrador+ABLE-3B  
 g Natal+CITE-3  
 h New-Mexico+ELCHEM  
 i Newfoundland+SONEX  
 j Ontario+ABLE-3B  
 k Pacific+CITE-2  
 l Philippine-Sea+PEM-West-A  
 m Philippine-Sea+PEM-West-B  
 n S-Africa+TRACE-A  
 o S-Atlantic+TRACE-A  
 p Tahiti+PEM-Tropics-A  
 q Tahiti+PEM-Tropics-B  
 r Tasmania+ACE-1  
 s US-E-Coast+ABLE-3B  
 t W-Africa+Coast+TRACE-A  
 u W-Brazil+ABLE-2A  
 v W-Tropical-Pacific+PEM-West-A  
 w Wallops+CITE-3



Note:

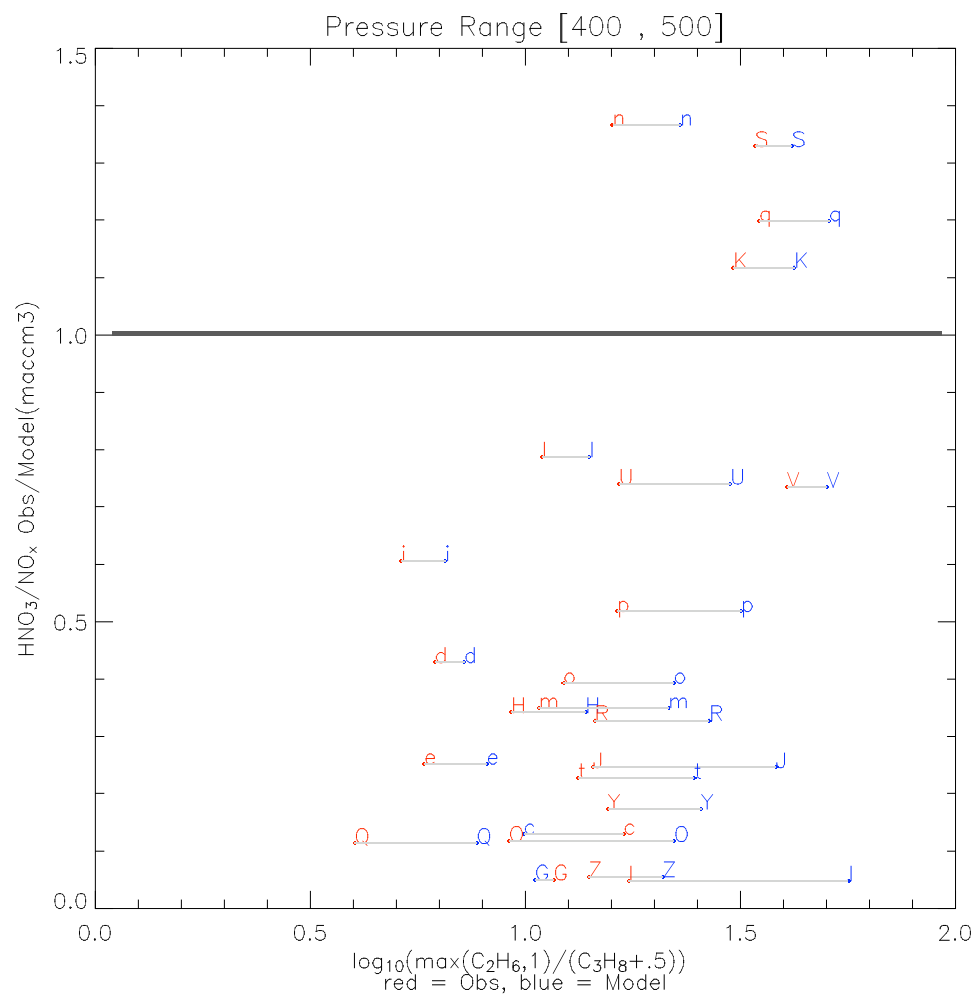
- Models tends to have more  $\text{HNO}_3$  per unit  $\text{NO}_x$  than Observations
- True for all meteorol. datasets
- Obs tend to have lower "age"

(or, less  $\text{NO}_x$  per unit  $\text{HNO}_3$ )

age of air →

$\int [\text{OH}] dt$   
 ... as in GEOS-Strat to GEOS-3 (says Jacob)

B Alaska+ABLE-3A  
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 D Calif+Coast+CITE-1B  
 E Canary-Islands+POLINAT-2  
 F Central-US+SUCCESS  
 G China-Coast+PEM-West-A  
 H China-Coast+PEM-West-B  
 I China-Coast+TRACE-P  
 J Christmas-Island+PEM-Tropics-A  
 K Christmas-Island+PEM-Tropics-B  
 L E-Atlantic+POLINAT-2  
 M E-Brazil+ABLE-2A  
 N E-Brazil+ABLE-2B  
 O E-Brazil+TRACE-A  
 P E-Brazil-Coast+TRACE-A  
 Q E-Atlantic+SONEX  
 R Easter-Island+PEM-Tropics-A  
 S Easter-Island+PEM-Tropics-B  
 T Europe+POLINAT-2  
 U Fiji+PEM-Tropics-A  
 V Fiji+PEM-Tropics-B  
 W Hawaii+CITE-1B  
 X Hawaii+PEM-Tropics-A  
 Y Hawaii+PEM-Tropics-B  
 Z Hawaii+PEM-West-A  
 a Ireland+POLINAT-2  
 b Ireland+SONEX  
 c Japan+PEM-West-A  
 d Japan+PEM-West-B  
 e Japan+TRACE-P  
 f Labrador+ABLE-3B  
 g Natal+CITE-3  
 h New-Mexico+ELCHEM  
 i Newfoundland+SONEX  
 j Ontario+ABLE-3B  
 k Pacific+CITE-2  
 l Philippine-Seo+PEM-West-A  
 m Philippine-Seo+PEM-West-B  
 n S-Africa+TRACE-A  
 o S-Atlantic+TRACE-A  
 p Tahiti+PEM-Tropics-A  
 q Tahiti+PEM-Tropics-B  
 r Tasmania+ACE-1  
 s US-E-Coast+ABLE-3B  
 t W-Africa-Coast+TRACE-A  
 u W-Brazil+ABLE-2A  
 v W-Tropical-Pacific+PEM-West-A  
 w Wallops+CITE-3

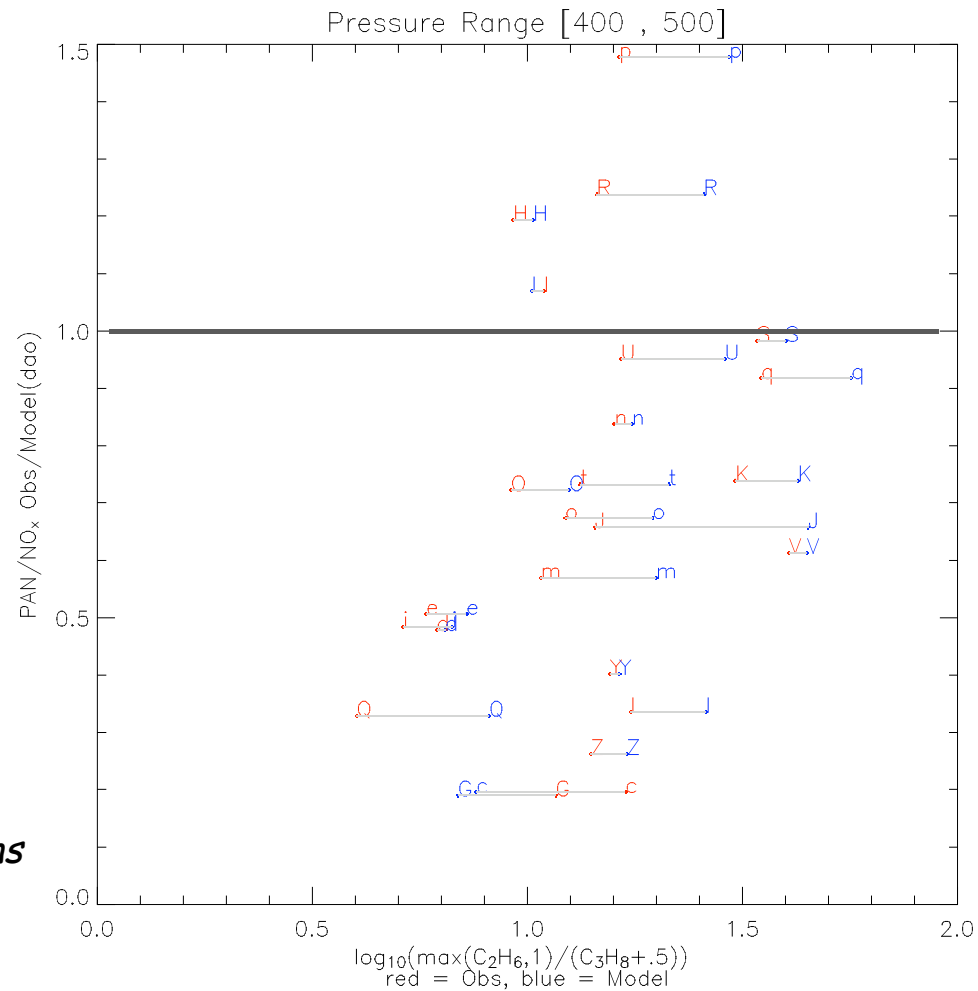


**Note:**

• *MACCM3 seems to have more spread in age than DAO (GEOS-STRAT)*

PAN also shows similar

B Alaska+ABLE-3A  
C Calif+CITE-2  
D Calif+Coast+CITE-1B  
E Canary-Islands+POLINAT-2  
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t W-Africa-Coast+TRACE-A  
u W-Brazil+ABLE-2A  
v W-Tropical-Pacific+PEM-West-A  
w Wallops+CITE-3



1:1

Models tends to have less  
PAN per unit NO<sub>x</sub> than Observations

$$\frac{[\text{PAN}]_{\text{obs}}/[\text{NO}_x]_{\text{obs}}}{[\text{PAN}]_{\text{mod}}/[\text{NO}_x]_{\text{mod}}}$$

Simple T effect?

... as in GEOS-Strat to GEOS-3 (says Jacob)

## *Overdisperse Sources of NO<sub>x</sub>*

Strong diel pattern of aircraft emissions over the US suggests that repeated "pulses" of NO<sub>x</sub> move away from N. America.

- (1) Too much modeled NO<sub>x</sub> or too little NO<sub>y</sub>  
in the HNO<sub>3</sub>/NO<sub>x</sub> and PAN/NO<sub>x</sub> ratios
  - tropospheric "age of air" is better in DAO compared to MACCM3, GISS
- (2) NO<sub>x</sub> from aircraft: one day's flights: 7:1 diel variation over U.S.  
We would not tolerate inaccuracies of this sort f